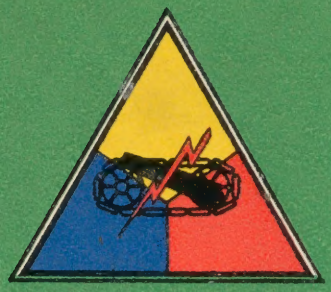

ARMORED FORCE
MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

Report On

CARBON MONOXIDE HAZARD FROM AUXILIARY GENERATORS IN TANKS

Project No. 3-12

December 20, 1942

ARMORED FORCE MEDICAL RESEARCH LABORATORY
Fort Knox, Kentucky

Project No. 3-12
File No. 723.13-1

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CARBON MONOXIDE HAZARD FROM AUXILIARY GENERATORS IN TANKS

1. PROJECT: Determination of the carbon monoxide hazard from auxiliary generators in tanks.

a. Authority - Letter of Commanding General, Headquarters Armored Force, Fort Knox, Kentucky, 400.112/6 GNOHD, dated September 24, 1942.

b. Purpose - To determine the magnitude of the carbon monoxide hazard resulting from the operation of auxiliary generators in tanks when the tank motor is not running and to test the effectiveness of corrective measures.

2. DISCUSSION:

a. Methods - Four M-4 tanks were tested, representing four different conditions of discharge of the exhaust gases from the auxiliary generator, as follows:

M4A1 ---- with exhaust pipe terminating in the air-exit area at rear of tank. (Fig. 2)

M4A2 ---- with exhaust pipe terminating outside the rear wall of the engine compartment and between it and muffler. (Fig. 2)

M4A3 ---- with exhaust pipe terminating within the engine compartment. (Fig. 1)

M4A2 ---- with exhaust pipe terminating outside the rear wall of the engine compartment and below the curved baffle plate provided for the deflection of the tank motor exhaust gases. (Fig. 3)

In addition, the effect of extending the exhaust pipe beyond the overhanging armor at the rear of the tank was determined. The tank in each case was located in an open yard and oriented so as to provide a tail wind. Carbon monoxide concentrations were determined at three positions: at the radiator in the bulkhead and at the breathing zones of the loader in the turret and the driver in the bow. The tank was in all cases buttoned up; tank engine not running.

Detailed description of tests and the results obtained are presented in the Appendix.

3. CONCLUSIONS:

a. Operation of the auxiliary generator with the tank motor not running produces a definite carbon monoxide hazard in the fighting compartment of all of the M-4 series of tanks tested.

b. Discharging the auxiliary engine exhaust gases to the outside at the rear of the engine compartment reduces, but does not eliminate the hazard as compared with discharging within the engine compartment.

c. Discharging the exhaust gases in any upward direction beyond the overhanging armor at the rear of the tank reduces still further the carbon monoxide concentration within the tank.

d. The best results were obtained when the exhaust pipe terminated outside and below a plate provided for the deflection of the main engine exhaust gases.

4. RECOMMENDATIONS:

a. The exhaust pipe from the auxiliary generator should be extended outside the rear wall of the engine compartment and be terminated at a point free from obstruction so that the exhaust is not deflected toward the air intake or exit openings in the engine compartment. The best location is believed to be near the bottom and to the side of the rear wall. (Fig. 3)

b. When a main exhaust deflector plate is provided, the auxiliary exhaust should be located below it and approximately ten (10) inches from the rear wall of the engine compartment.

c. All connections from the auxiliary generator engine to the exhaust pipe and other joints should be properly gasketed and maintained to prevent direct leakage into the fighting compartment.

d. Whenever possible hatches should be opened when the auxiliary generator is being operated with the tank engine not running.

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Commanding

APPENDIX

The terminal exhaust from the auxiliary generators in the M-4 tanks is badly located from the standpoint of leakage of exhaust gases back into the fighting compartment. When the tank engine is not running and the tank is subjected to a tail wind, pressure builds up in the engine compartment and forces the contamination back into the fighting compartment. The situation is particularly bad in the M4A3 tank in which the auxiliary generator exhaust terminates within the engine compartment. In the M4A1 and M4A2 conditions are better but not satisfactory. In the former, the discharge is in the air-exit area at the rear of the tank and in the latter it is outside the rear wall but is obstructed by the main engine muffler. Under conditions of a tail wind, the exhaust gases, even from these locations, are forced back, in part, into the fighting compartment. Results of tests upon these three types of tanks follow.

a. M4A3. Carbon monoxide concentrations are shown in Fig. I. Concentrations were highest at the radiator, but were found to be greatly in excess of permissible levels in the bow. There was a rapid distribution of the contamination within the tank, with concentrations ranging, during the test, from 0.03 to 0.10 percent carbon monoxide.

b. M4A2. In this model the exhaust pipe passes through the engine compartment and terminates outside between the rear wall and the muffler. The latter acts as a baffle which deflects the exhaust gases, some of which rise and return into the engine compartment through the main engine radiator and thus find their way back into the fighting compartment. Carbon monoxide concentrations at the three sampling locations are all shown in Fig. 2. The ranges in concentrations under the conditions of test were:

1. Radiator: 0.065 to 0.087 per cent carbon monoxide

2. Loader : 0.045 to 0.060 per cent carbon monoxide

3. Driver : 0.035 to 0.052 per cent carbon monoxide

c. M4A1. The exhaust pipe in this case terminates just inside the armored air-exit opening at the rear of the engine compartment, discharging at a downward angle through the screened opening. Under conditions of a tail wind, the exhaust gases are trapped to a considerable degree and return through the engine compartment to the fighting compartment. Carbon monoxide concentrations are shown in Fig. 2. Ranges in concentrations were:

1. Radiator: 0.070 to 0.090 percent carbon monoxide

2. Loader : 0.067 to 0.083 percent carbon monoxide

3. Driver : 0.057 to 0.063 percent carbon monoxide

The results obtained with these standard tanks indicated clearly

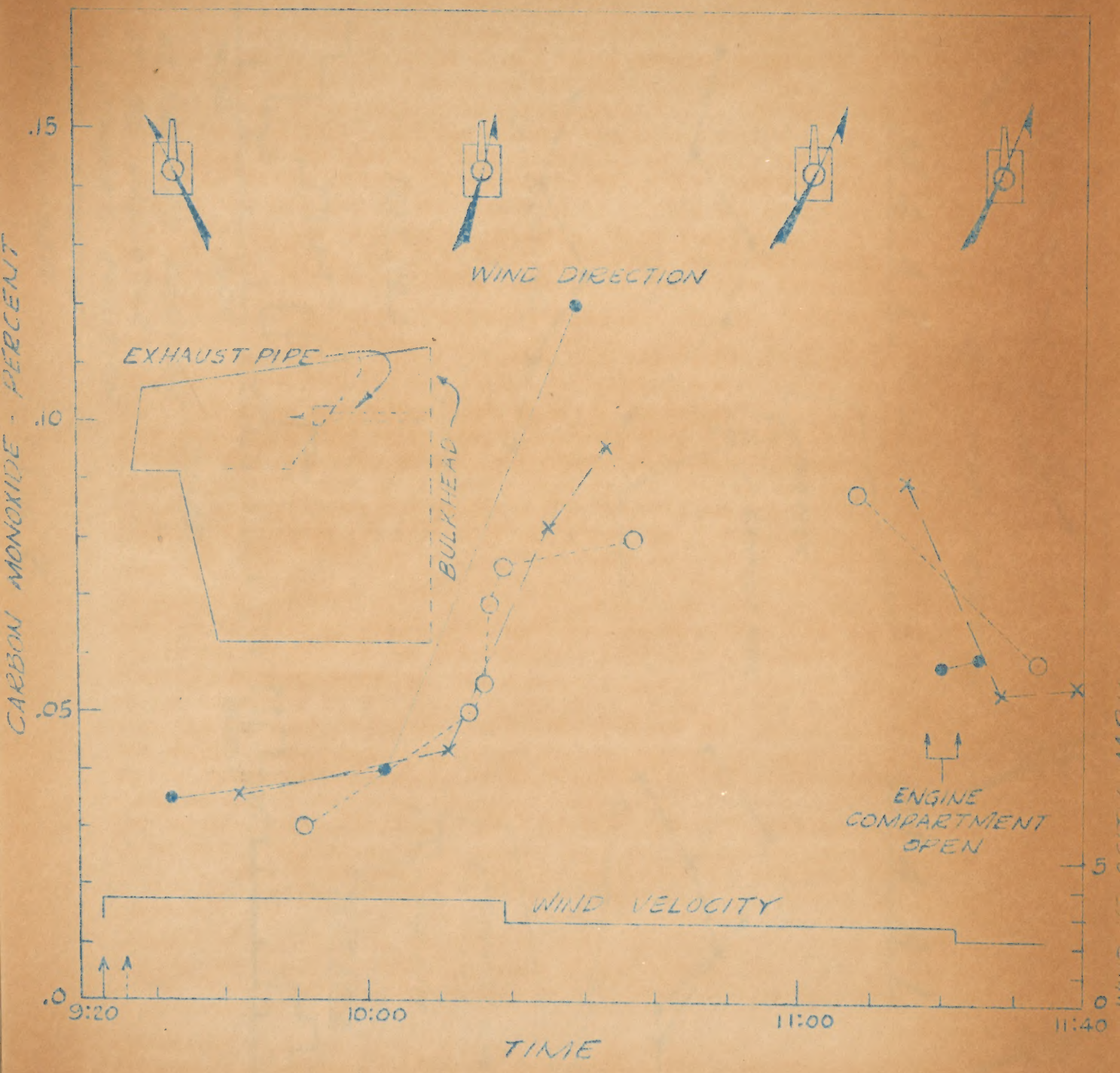
the need for corrective measures. Further tests were therefore conducted upon a modified M4A2 tank provided with a baffle plate for the deflection of the main engine exhaust gases. Two conditions were tested:

1. With exhaust pipe extended beyond the overhanging section at the rear of the tank and arranged to discharge in an upward direction.

2. With the exhaust pipe terminating below the main exhaust deflector and at a distance of 10" from the rear wall of the engine compartment.

For comparison, carbon monoxide concentrations were determined with the exhaust discharging above the main exhaust deflector at such a point that the gases traveled upward into the overhanging air-exit area. The results are shown in Fig. 3. With the terminal discharge beyond the overhang and in an upward direction conditions were better than in any of the standard tanks but not altogether satisfactory since some of the gas spilled over the top of the engine compartment and down through the main air intake into the fighting compartment. This shows that correction of the situation is not merely a matter of extending the exhaust pipe out through the rear wall. It must discharge finally at a point where there is little possibility of its being carried back into the tank. It is believed that the preferable location is near the bottom of the tank and to one side of the rear wall.

The most favorable results were obtained with the exhaust pipe terminating beyond the rear wall and below the main exhaust deflector plate. The action of the latter was to prevent the exhaust gases from rising directly into the air-exit area at the rear of the tank. It may be concluded that with exhaust deflector plates installed on tanks, no serious problem will arise (for periods of operation of from 1 to 2 hours) with respect to the exhaust gases from the auxiliary generators when the exhaust pipe terminates below the deflector plate.


.15
.10
.05
.0
CARBON MONOXIDE - PERCENT
WIND DIRECTION
EXHAUST PIPE
BULKHEAD
ENGINE COMPARTMENT OPEN
WIND VELOCITY
5
0
9:20
10:00
11:00
11:40
TIME
O-O CO AT DRIVERS POSITION
●-● CO AT RADIATOR
x-x CO AT LOADERS POSITION
---> HOMELITE STARTED
——> HATCHES CLOSED

M-4 A-3

Fig. 1

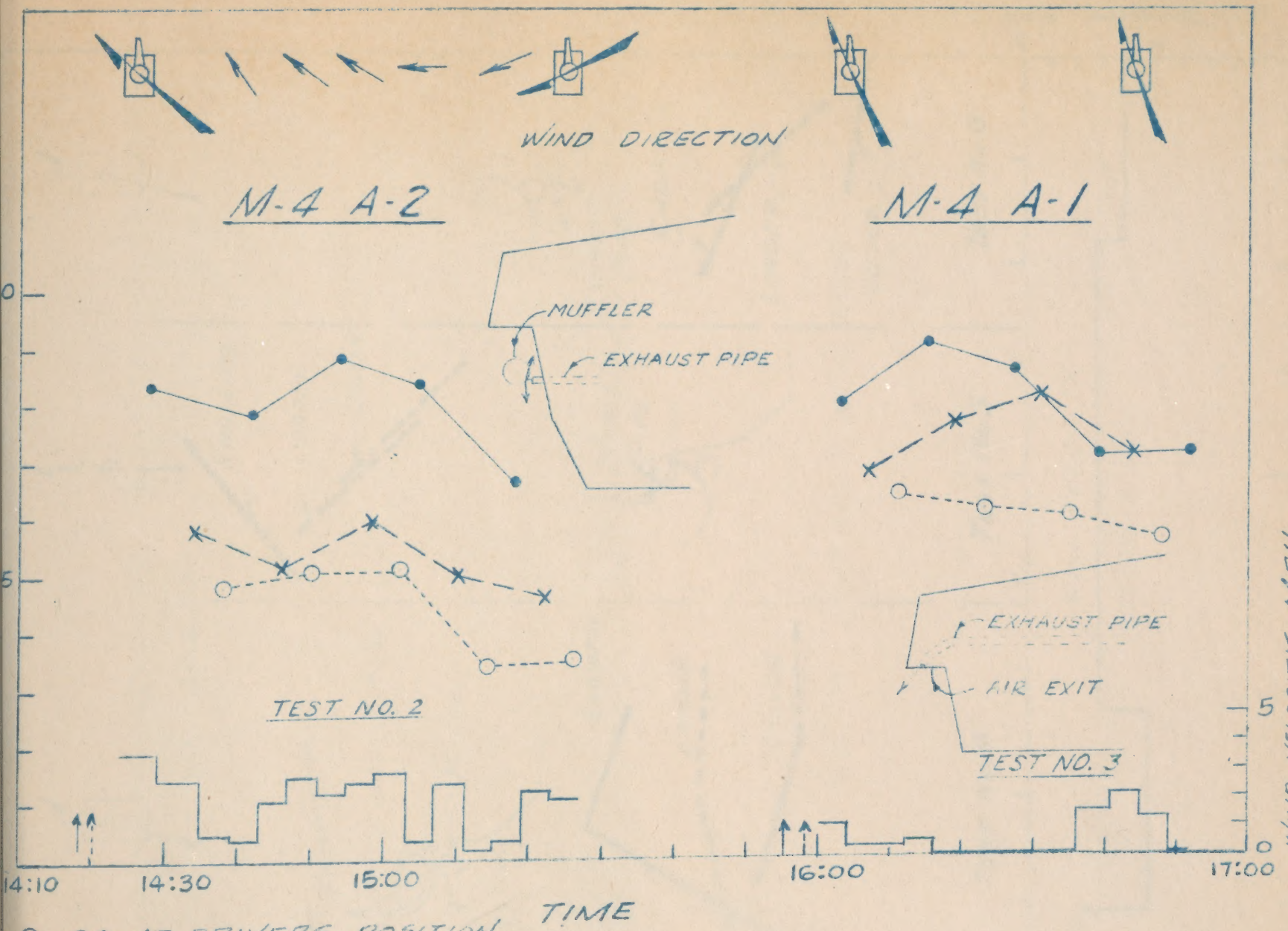
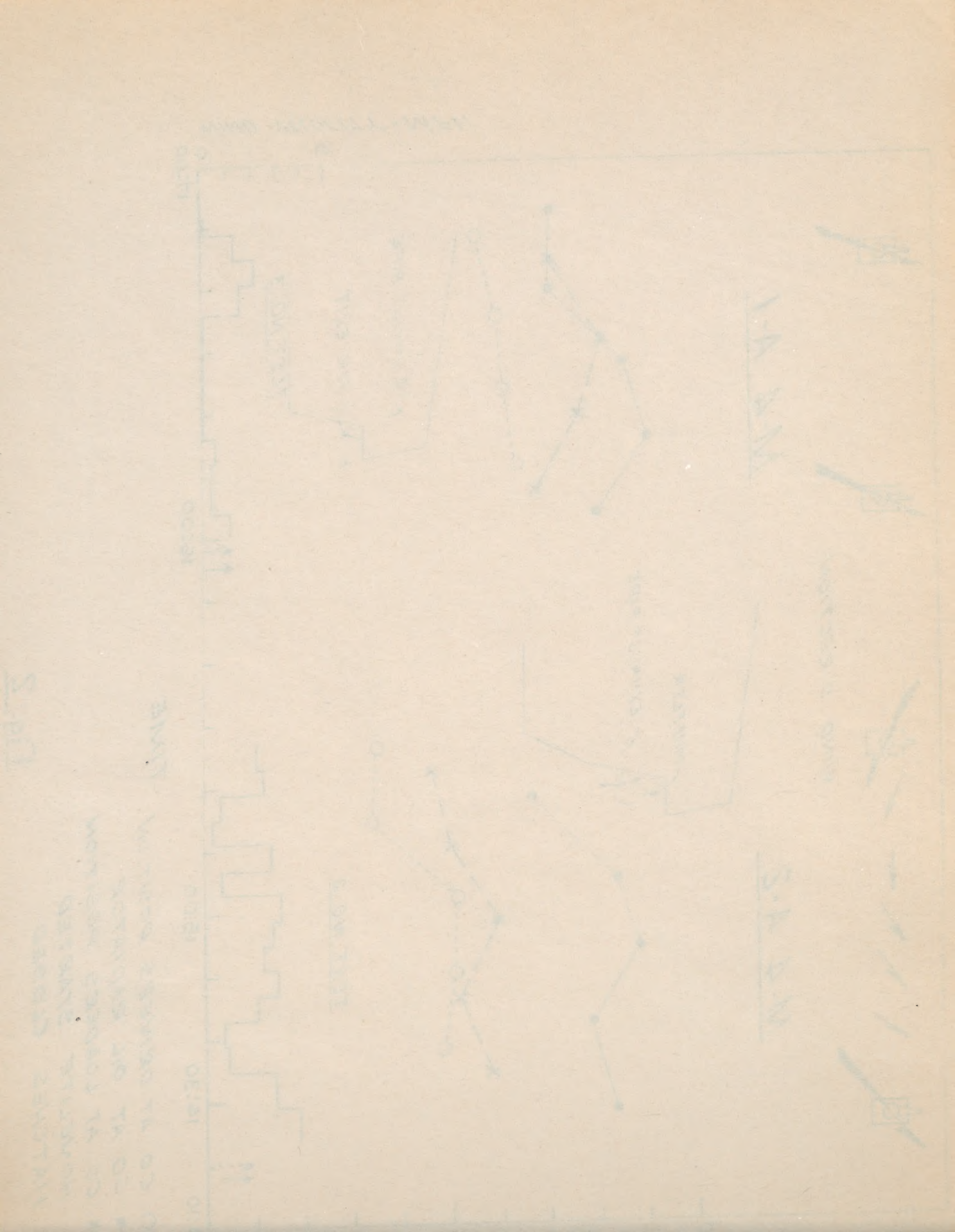

WIND DIRECTION
M-4 A-2
M-4 A-1
MUFFLER
EXHAUST PIPE
EXHAUST PIPE
AIR EXIT
TEST NO. 2
TEST NO. 3
WIND VELOCITY - MPH
0
5
0
5
14:10
14:30
15:00
16:00
17:00
TIME
CO AT DRIVERS POSITION
CO AT OIL RADIATOR
CO AT LOADERS POSITION
HOMELITE STARTED
HATCHES CLOSED

Fig. 2



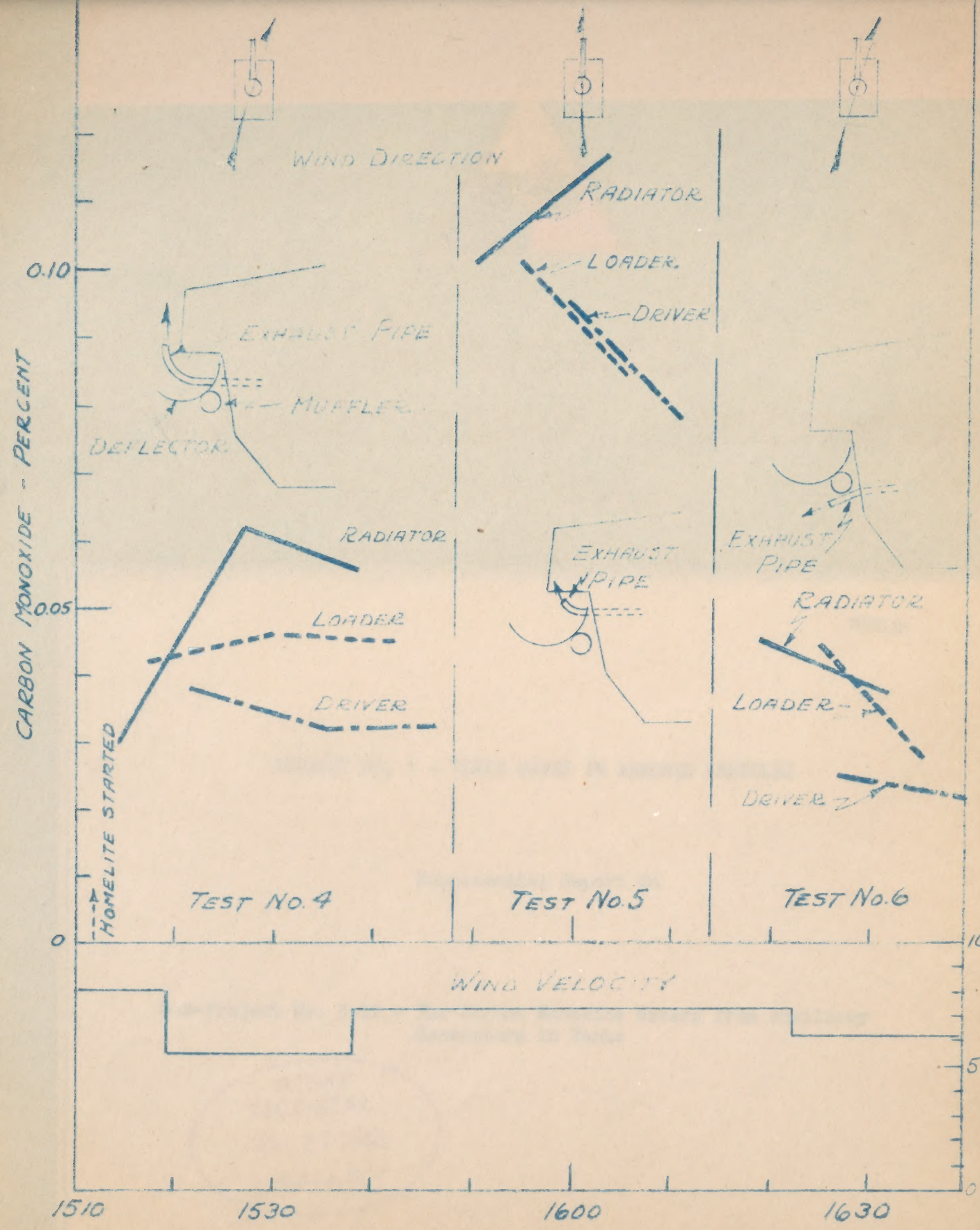


FIG. 3

M-4A-2
WITH MAIN EXHAUST
DEFLECTOR